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Agricultural Research

Floral Crops;
More To Pick From
(page 4)

Who Owns the World's Plant Genes?

When you planted that vegetable garden earlier this year, did you stop to think where those seeds came from? They may have been harvested and sold by a company in a neighboring state, but what was their real origin? In which countries did they evolve? Who crossbred and improved them over the years?

The truth is, all our major garden and field crops were brought here from other countries. And your right to plant these crops without paying the countries of origin and intermediaries a fee is now being debated.

Under this line of reasoning, Mexico might one day expect to receive payment for any corn we plant, China for any rice and soybeans, and Syria for small grains. The United States would get royalties from other countries that plant our native cranberries and sunflowers.

This is a very controversial proposal that illustrates the complexity of deciding who really "owns" what.

And how much is a single gene worth? What is the minimum fraction of outside germplasm in a plant pedigree that warrants a commercial royalty benefit?

In conventional breeding, varietal development is hard work and requires many years. Soon, plant performance will be linked with genetically engineered genes, the full value of which may only be recognized sometime later.

And it will be difficult to identify which country's material supplied a gene that imparts a certain characteristic, as for example making plants more drought resistant. Maybe it will be a combination of genes from two countries' plants, selected by plant breeders in a third country, and further improved by genetic engineers in a fourth country.

If plants and genes get tied up in courts and become unavailable for breeding improved varieties, there could eventually be less food available and more world hunger. As the world population expands from its current level of 5.7 billion to about 10 billion over the next half century, food issues are likely to become increasingly more important—and difficult to resolve.

It seems clear that the objectives of all concerned groups should be to support fair and equitable sharing of genetic resources between the sources and users. But while the international community recognizes this, there is less agreement on how it might be accomplished.

The Convention on Biological Diversity, which took effect last December, has a provision that some of the benefits of commercialization should be shared with the country providing the germplasm. Currently, several international organizations, including the Food and Agriculture Organization of the United Nations (FAO), are struggling with the issue. Negotiations are scheduled to begin at FAO's Rome headquarters in November 1994.

Historically, germplasm has been openly and freely exchanged among scientists and between gene banks.

International agricultural research centers of the Consultative Group on International Agricultural Research develop new varieties of major food crops. The centers manage major collections of plant genetic resources, including farmer varieties and wild species acquired mostly from developing countries. Developed countries provide breeder varieties, breeder lines, and research genetic stocks.

Associated biocontrol organisms, symbiotic and other beneficial microbes, and animal and aquatic breeding stocks are equally affected by the biological diversity convention.

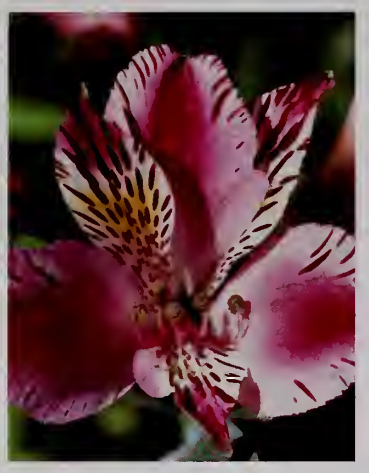
Scientists in the public and private sectors alike will have new obligations—and new opportunities—when they acquire germplasm abroad. The convention provides a two-way street, establishing some parallel with the intellectual property system and its royalties and benefits from commercialization.

To say there will soon be a simple solution to the complicated germplasm compensation problem would be overly optimistic. The solution will have to address all aspects of ownership.

It will be everyone's charge to ensure that discussions not dissolve into chaos. And that will not be easy, because we have myriad opinions even within our own scientific community and governing bodies.

Henry L. Shands
Associate Deputy Administrator
Genetic Resources

Agricultural Research



Cover: An *Alstroemeria* hybrid being evaluated for heat tolerance by scientists in the USDA-ARS Floral and Nursery Plants Research Unit in Beltsville, Maryland. Commonly called the Peruvian lily, it has multiple 2-inch blossoms. Photo by Scott Bauer. (K5544-7)

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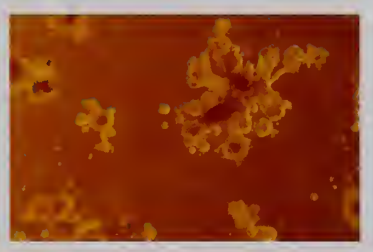

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Horticulturists Mark Roh (left) and Roger Lawson display new flowers developed for U.S. consumers. (K5551-17)

New Flower Power!

"Developing a new floral crop involves a long gestation, and the outcome may be unpredictable," says Roger H. Lawson.

After 14 years of experience leading what is now the ARS Floral and Nursery Plants Research Unit—and nearly 10 years of directing a new crop development program—Lawson has learned this lesson firsthand.

Tacitus bellus (K5548-12)

SCOTT BAUER

Fire lily, a *Cyrtanthus* hybrid. (K5547-7)

Recently, the Florist and Nursery Crops Laboratory at the Beltsville (Maryland) Agricultural Research Center was combined with scientific staff of the U.S. National Arboretum in Washington, D.C. The purpose: to strengthen research on tree, shrub, and floral crops.

K. Darwin Murrell, director of the Beltsville area that includes the arboretum and laboratories based at the center, says the new partnership combines the arboretum's operating budget and research staff with those of the Beltsville lab to form a new floral and nursery plants research team. Its yearly $3.2 million budget, 13 scientists, and 39-employee staff are now assigned to the arboretum.

"We have merged together some of the finest scientific expertise in landscape and nursery plant research," says Murrell.

His praise is well deserved. For more than 30 years, researchers in the Florist and Nursery Crops Laboratory have introduced many floral crops. Examples include the impatiens that have become the No. 1 bedding plant and longer lasting poinsettias, the leading flowering potted Christmas plant. Today, the lab is well-known for its use of genetic engineering techniques to develop new varieties and pathogen-free plants.

"New-crop development is a high-risk venture that few companies can afford," Lawson says. "Collecting, evaluating, and introducing new floral crops often involves a major investment of time and money. Frequently, results are realized only after many years.

"It all takes time and patience," he adds, "but the results are well worth the effort. In fact, survival and expansion of the floral market depends on it."

SCOTT BAUER

***Clematis* hybrid. (K5546-17)**

Keeping Up and Staying Competitive

The floral, nursery, and landscaping industry is one of the fastest growing sectors in agriculture.

According to the Society of American Florists (SAF) in Alexandria, Virginia, potted plants now account for about a sixth of the $12 billion U.S. floral and nursery industry. However, sales of U.S.-grown cut flowers have remained flat over the past few years.

Gene Gun May Broaden Color Range of Orchids and Other Flowers

A corn gene is giving ARS researchers a high-speed means to verify what the color of a new flower will be.

"If orchid plants are bred for a new color, it's anyone's guess about the outcome. Now, the plant industry usually waits 3 years, until a bloom appears," says Robert Griesbach, an ARS plant geneticist who is an expert on plant pigmentation.

"But we've found a corn gene that will give us results on the color of new hybrids in just 3 days."

The gene regulates pigment in corn plants.

When applied to microscopic gold pellets that are propelled into orchid flower petals, the gene helps screen for genetic flaws in the parent plants that might have been passed on to the new hybrids.

About one in a thousand orchid plants lacks adequate pigments, causing white or near-white flowers.

Griesbach says, "We have tested the technique successfully on bulb plants like gladiolus and other ornamentals, including petunias—as well as on orchids."

With the technique, "we can eliminate the misses. That should give plant breeders a higher degree of certainty in crossing various orchid colors such as purple and yellow, by cutting down on the number of unwanted color mutations. It could result in a broader range of colors in orchids and other ornamental plants."

He says the technique could be "a boon to breeders of orchids because of the flower's long generation time—up to 6 years in some commercial types." Orchid flowers are highly prized, he adds, noting that potted phalaenopsis orchids are "fast becoming a major economic crop.

A recent Associated Press article outlined how the U.S. flower industry is challenged because of cheap imports, limited selections, and increased competition through traditional outlets.

For U.S. producers to remain competitive in world markets, more new floral crops must be developed. And consumers would benefit by having a wider range of plants to choose from.

"On the surface, the process of developing new crops appears easy," Lawson says. "But the long road from initial selection of promising plant materials to evaluation, production, and marketing is filled with many obstacles and surprises."

To make the process easier, the SAF agreed in 1984 with the American Floral Endowment and several floral and nursery crop companies to support a program for developing new crops. The ARS Floral and Nursery Crops Laboratory was chosen to conduct the research.

The program was designed to increase the range of flower species available to U.S. producers. Its objectives included several broad areas of research:

• Conducting research on commercial production and distribution potential of new species acquired from individuals, researchers, and botanical gardens around the world.

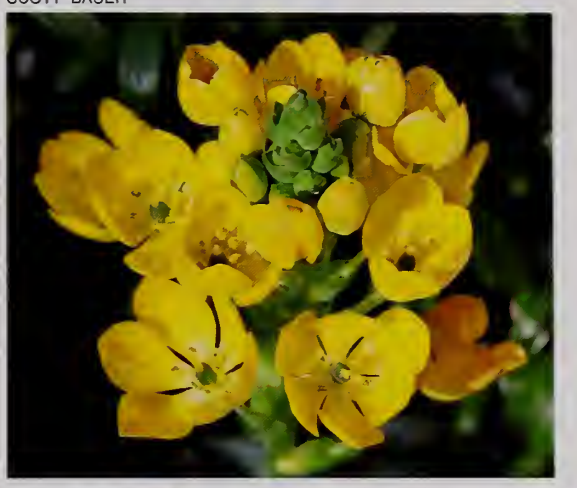
• Collecting and providing growers with detailed information on viable new crop alternatives.

• Promoting new crops with commercial market potential to the industry and public.

• Serving as an information source on new crops for growers and consumers.

Before beginning the new crops program, Lawson worked with Mark Roh and other ARS scientists at the lab to develop a list of candidate plants, based on their investigations of the problems and progress of new crop development in Europe, Asia, and Australia. Over the last 9 years, they imported over 40 different genera of cultivated and uncultivated plants from Europe, Asia, South Africa, and Australia.

SCOTT BAUER



Star of Bethlehem, an *Ornithogalum* hybrid. (K5547-19)

"We assumed that plants commercialized abroad—but not yet introduced into the U.S. market—might also be appealing to U.S. consumers," Roh says.

Early on, the research team realized that many of the plants they acquired would not be "off the shelf" items that could be brought directly into U.S. greenhouses and grown here commercially.

Evaluating each new plant was horticulturist Roh's responsibility. He started propagation on those

SCOTT BAUER

Plant geneticist Robert Griesbach cross-pollinates *Ornithogalum* flowers to produce a wider range of colors. (K5552-9)

In 1993, the wholesale value of orchids in Hawaii alone was nearly $11 million."

Griesbach tried the faster mutation screening on whole petals from orchid flowers (*Doritis pulcherrima* Lindl.). He bombarded the petals with gold pellets 10 times smaller than the dot at the end of this sentence. The microscopic pellets were coated with DNA obtained from corn plants by T.M. Klein of E.I. DuPont, Glascow, Delaware.

"Screening plants for color mutations is a new use for the gene gun that Griesbach demonstrated for the first time," says Roger Lawson, head of the ARS Floral and Nursery Crops Research Unit of the U.S. National Arboretum, Washington, D.C.

Over more than 2 years of tests, Griesbach found that the introduced corn genes caused near-white flowers to gain pigment within 48 hours after treatment. The purple color of the fully colored, wild-type flowers continued to develop for the next 24 hours.

"Eventually, the cells with the introduced corn genes looked the same as the purple cells found in wild plants, with no loss of pigment," Griesbach says.—By **Hank Becker**, ARS.

plants that survived and met the following criteria:

• Showed good display of bloom at first flowering and maintained quality for at least 14 days;

• Were easy to pack and ship; and

• Had a short enough production time to make the crop profitable.

And How Did the Flowers Grow?

"Some of the Australian imports, like kangaroo paw, were easy to propagate. Others, like *Cupressus* and Geraldton Wax flower, were more difficult to root," Roh says.

He nevertheless developed procedures to propagate these and many other species that include *Eucrosia* and *Erica*. Next, he learned how to control flowering of each candidate plant selected. Day length and temperature and nutritional needs were identified.

Many of the plants were shared with the industry support group and tests were also conducted under Roh's direction by university cooperators in California, Kentucky, Florida, Wisconsin, and Texas.

ARS plant geneticists Robert Griesbach and David Rubino worked with Roh on developing and testing new candidate plants. Griesbach developed a new dwarf kangaroo paw and is cooperating with Fred Meyer of New World Plants, Escondido, California, and Harold Koopowitz at the University of California at Irvine on breeding *Ornithogalum* (Star of Bethlehem). Rubino bred new forms of Sinningia and other gesneriads, as well as new forms of *Exacum* (Persian Violet).

After screening more than 60 plants in the program, they have introduced eight new crops:

Kangaroo paw, *Anigozanthous,* is grown as both a landscape plant and cut flower in its native Australia. But in Southern California, it is grown largely for cutting, with only limited interest in potted plants.

SCOTT BAUER

Wood sorrel, *Oxalis.* (K5545-17)

Using tissue culture, Griesbach developed and Roh tested two kangaroo paw hybrids. A dwarf form called Baby Roo has green and red flowers on 8-inch stems with 4-inch leaves. Roh discovered that year-round flowering of many Australian cultivars is possible by keeping the night temperature between 50°F and 55°F. Some selections flower at a higher temperature (above 60°F) with long days.

"Consumer acceptance of the potted plant hasn't met our expectations yet," says Roh. "Perhaps it's because the retail garden center price was about twice that of a 6-inch mum." All the consumer tests were conducted with plants bred in Australia.

Roh believes that Baby Roo should be market-tested as an indoor houseplant that can then be transplanted into the garden in southern climates. "In Florida, where it flowers continually, it has been grown as a garden plant."

Geraldton Wax flower, *Chamelaucium,* is an Australian shrub that produces many small, white-to-pink flowers with excellent keeping quality. Selections made in Australia have been grown for cutting in Southern California for several years. But ARS research on developing improved methods of propagating and controlling flowering has shown that the plant can be adapted to pot culture.

Most adaptable is the Purple Pride cultivar, since it has a natural dwarf form. Its growth habit tends to be open, so it needs three or four pinching off of branch tips to form a more compact plant. This should be done before flowering is induced by short days.

Cuttings, propagated from January through March, can be sold as finished plants by October.

"If properly grown, this plant can be very showy because even though each individual flower is small, it produces a large number of them. Purple Pride will require some grower patience and some experience, but it has the potential to become an important addition to the market," Roh says.

Sinningia cardinalis, when propagated from seed, produces a mass of orange-red or pure-white tubular flowers in just 6 to 7 months. "The plant has been around for many years, but these new forms are worthy of renewed attention," he says. "For those who like gloxinias, *Sinningia* may be a desirable plant."

Correa Mannii is an Australian fuchsia that has adorned gardens there and in California for many years. Its tubular flowers are red on the outside and a pale orange-red inside. They keep their vibrant color for more than 2 weeks indoors and last for over a month.

Roh determined that *Correa* will flower when subjected to a long-day photoperiod, and it responds well to nitrogen fertilizer.

SCOTT BAUER

Horticulturist Mark Roh examines a dwarf *Clematis* hybrid grown as a potted plant. (K5549-16)

"A vigorous plant with many flowers will be produced by adding a slow-release fertilizer to the growing medium and by adding supplemental water-soluble fertilizer at an increasing concentration throughout the growing season," he says.

In the North, *Correa* can be grown as a summer patio plant. In the South, it will survive as a perennial.

Clematis (dwarf)—not the same as the popularly grown vine, this newcomer to the U.S. market is a well-known potted plant in Japan. Evaluated by Roh for dwarf stature, plants produce 4- to 5-inch blooms of blue, white, or pink that last at least 10 days indoors.

"ARS research has focused on improved propagation methods and root-storage tests to find out how long dormant plants can be stored. We have tried to extend the forcing period and produce a finished plant over a longer period," he says. Production could be timed for forcing potted plants for indoor growth and blooms, then planting them outdoors.

According to Lawson, "market tests last Easter at the Behnke Nurseries Co. in Beltsville proved the dwarf clematis sold very well, especially when considering the competition from standard seasonal plants like lilies and azaleas."

***Eucrosia* bicolor,** a member of the amaryllis family, has bright-red petals and sepals and long, yellow stamens. It is grown as a cut flower, each bulb producing a single cluster of 6 to 8 flowers per stem. Flowers last about 5 to 6 days. Additional breeding is being done to develop new hybrids to extend the range of available colors.

Eucrosia flowers only once a year, around March in a greenhouse. However, flowering can be extended from December to May by storing bulbs at various temperatures.

Star of Bethlehem, *Ornithogalum,* is best known as a cut flower. Orange, salmon, and canary yellow flowers bloom on tall stems. Besides these new cut-flower types, seedlings suitable for potted plants were developed that combine the orange color, short stem, and tight clusters of numerous flowers. The best seedlings were propagated, and selections are being commercially evaluated.

***Eustoma*,** lisianthus, is a dwarf with purplish-blue, bell-shaped flowers that last up to 14 days. Little Belle Blue was developed as the first true genetic dwarf selected from tissue culture. Outdoors, it makes a great bedding plant that will bloom for up to 2 months. White- and pink-flowered plants are being developed. Grown for use in either flower pots or beds, it can be sold as a seed-produced plant.

Says Lawson, "A commercial grower in Florida reported that he is so pleased with Little Belle Blue he is growing 30,000 plants for sale this year."

Research is also being done on *Curcuma, Lachenalia, Oxalis, Erica,* and *Leptospermum.* Growing protocols for these and other crops will be available in the future.

"With growers' support, the new-crops program will have an expanding base that will help ensure that U.S. consumers will have interesting new cut flowers and potted plants now and in the 21st century," Lawson says.

According to Drew Gruenburg, senior vice president of the Society of American Florists, "The new-crop development program is a unique example of the success of private industry and government working together. We couldn't have done it on our own."—By **Hank Becker,** ARS.

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Erosion Study Crosses the Border

J.R. SIMANTON

On heavily grazed grass upland areas near Mazatan, Mexico, ARS and CIDESON scientists use a rainfall simulator to conduct research and collect data on potential erosion problems. (94-92)

The recently signed North American Free Trade Agreement, or NAFTA, will permit greater exchange of goods—especially agricultural products—from Mexico into the United States and from the United States into Mexico.

This increased trade should stimulate both countries to develop more productive agricultural bases. So the relatively fragile lands near the shared border will be under pressure to produce both food crops and meat from grazing livestock.

But this development need not cause degradation of natural resources and disastrous erosion such as occurred when early settlers plowed up millions of acres of native grasslands in the Great Plains. Those practices continued until the mid-1930's, when a prolonged drought led to disastrous wind erosion over large areas. Soil from that Dust Bowl was blown as far as 1,500 miles eastward, clouding skies above New York City. Other areas in the West sustained damage from overgrazing.

"Fortunately, we have today much more information that we can use to prevent similar environmental disasters from occurring," says ARS hydrologist Leonard J. Lane. He heads the Southwest Watershed Research Center in Tucson, Arizona. "We are now adding to that database through a cooperative project aimed at protecting millions of acres in the southwestern United States and northern Mexico."

Some may wonder why research emphasis should be focused on an area of the continent that is less productive than the more familiar farm belts in the Midwest. But arid and semiarid rangelands make up about 40 percent of the Earth's land surface. They are the source of products valued at more than $1 billion annually in the United States alone.

ARS and a cooperating agency in Mexico, the Centro de Investigacion y Desarrollo de los Recursos Naturales de Sonora (CIDESON), are midway through a 2-1/2 year cooperative project—the first ever involving the two research organizations. USDA's Office of International Cooperation and Development is providing funding.

Says Hector Arias Rojo of Hermosillo, Sonora, who heads the project for CIDESON, "Conservation

J.R. SIMANTON

Hector Arias Rojo, CIDESON lead scientist for the Matape Project, and CIDESON ecologist Maria Luisa Fernandez test soil compaction near the Mazatan rainfall simulation plots. (94-91)

and preservation of our natural resources and their economic and environmental sustainability are among the highest priorities at all levels of our society and between our nations. Single or limited natural resource and economic development goals will result in operations that are not profitable or environmentally safe. This type of cooperative research is essential for sustainable natural resources in Mexico."

"And," says Lane, "it does no good to have a profitable farming operation if it destroys the local communities and environment. Future natural resource planning and management will have many objectives—economic, cultural, social, and perhaps others. Our goal is to provide the scientific knowledge and technology

for sustainable use of our natural resources in agriculture.

"Ultimately, however, farmers and ranchers must decide that it is in their own interest to adopt natural resource management and conservation technologies, says Lane. "Future planning and management will consider all these factors."

ARS hydraulic engineer Mary H. Nichols heads the ARS-CIDESON project at Tucson. She says that one of the main challenges will be to determine how best to apply what is already known about the effects of different farming and ranching practices on soil erosion, water runoff that can remove agricultural chemicals, and soil properties that contribute to fertility and plant growth.

J.R. SIMANTON

Transition zone between grass and shrublands at the Walnut Gulch experimental watershed near Tombstone, Arizona. (94-93)

For the Record

Impressive information has already been documented.

The Walnut Gulch Experimental Watershed near Tombstone, Arizona, is considered to be "hydrology heaven" by some engineers and scientists; it has generated more natural resource data per acre than any comparable area in the world. The 58-square-mile site has been intensively measured since 1954, yielding data that formed the core of many natural resource computer programs now used to help protect the environment. (See also "When the Hard Rains Come," *Agricultural Research,* Nov. 1992, pp. 4-9.)

Measurements collected over the past 40 years describe topography, soils, vegetation, and land-use characteristics and include precipitation, runoff, erosion, and sedimentation data. The long precipitation record from a dense network of more than 60 recording rain gauges was used to modify national rainfall frequency atlases that are used in predicting flooding.

"But the rule for Walnut Gulch may be the exception just across the border," says Nichols. "We need to extend this information to other areas that are much larger and where soil and weather conditions may be different. Our starting point is the 1,150-square-mile Rio Matape Watershed in Sonora, Mexico, about 200 miles south of our research center. Slightly larger than the state of Rhode Island, this watershed contains both desert and savanna grasslands."

This past April was the second time that ARS hydrologists John R. Simanton and Howard D. Larsen led a team of U.S. and Mexican scientists, engineers, technicians, and students in performing studies on test sites within the Sonoran watershed.

They used a trailer-mounted rainfall simulator with ten 25-foot rotating booms to create their own series of rainstorms. The first artificial storm was run for 45 minutes with water applied at the rate of 2-1/2 inches per hour. A second storm created 24 hours later ran for 23 minutes, and a third followed only 30 minutes later on the already wet soil.

"We collected and measured the amount of soil and water that washed off each of our plots, which were selected to represent a wide range of soil types, groundcover, and land use practices," says Simanton. "So far, our preliminary data indicate that potential erosion problems in Mexico share many similarities with ones we encounter in Arizona."

The Tucson personnel worked with and taught their Mexican counterparts how to design and collect data from rainfall simulator experiments.

"This practical, extensive, on-site training will facilitate future cooperative research and technology transfer efforts," says Simanton. "By having a consistent way to gather information, we can easily compare findings from one location to the next."

Model Simulation Also Helps

A computer model developed by ARS scientists in Temple, Texas, and Durant, Oklahoma—called Simulator for Water Resources on Rural Basins-Water Quality, or SWRRB-WQ—is being used in the project.

It was calibrated using data collected on the Walnut Gulch Watershed from 1967 to 1977 to simulate hydrologic and related processes on the watershed.

It is now being expanded to include subareas on the Rio Matape Watershed using actual on-site rainfall simulation data and other applicable small-watershed data.

Once calibrated, models like SWRRBWQ are useful tools for evaluating the effects of farm and ranch operations on water runoff.

And the new data being collected in Mexico will help expand the usefulness of other natural resource models, including the Revised Universal Soil Loss Equation (RUSLE) and the Water Erosion Prediction Project (WEPP).

Although weather data from Mazatan, a small town located within the watershed, have been recorded, they are not detailed or complete enough for scientific use.

So the project cooperators recently installed three meteorological stations and more than a dozen additional rain gauges to close information gaps discovered during the first part of the study.

"After the SWRRBWQ model is fine-tuned to properly estimate water and sediment yield, we will add crop and land use information to see if it's possible to accurately evaluate effects of alternative management practices," says Nichols.

Areas that are suited for marginal dryland farming will be tested to find the best way to improve agricultural yields—mostly from forage and some cultivated corn—and to reduce soil erosion.

"The Rio Matape Watershed is one of four included in a proposed binational U.S.-Mexico project being developed by ARS and INIFAP (Instituto Nacional de Investigaciones Forestales y Agropecuarias), the Mexican equivalent of ARS," says Lane.

Mexico recently allocated money to build a new national laboratory dedicated to promoting sustainable agriculture.

Collected data and simulation models will be used to build hybrid databases for both Walnut Gulch and Rio Matape watersheds. Eventually, scientists will include them in decision support systems, the user-friendly procedures that weigh hundreds of interconnected factors and help rank alternatives for managers.—By **Dennis Senft,** ARS.

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Cheese Pizza—Hold the Fat

Whether it's dine-in, pick-up, or delivery, one common denominator exists in pizza—fat.

No matter how you slice it, Americans consume about 100 acres of pizza each day, according to the National Association of Pizza Operators and *Pizza Today*. This translates to an average of 7.7 pounds of that delicious, stringy mozzarella cheese topping, per person, each year.

For the diet-conscious, several brands of low-fat mozzarella are now on the market. But many consumers find today's low-fat mozzarella unacceptable, and few pizzerias are ready to trade the cheesy quality of their regular, or full-fat, product for a minimal fat reduction (5 to 7 percentage points) gained by using low-fat mozzarella cheese.

So scientists with the Agricultural Research Service have been addressing this quality issue.

SCOTT BAUER

"We have developed a type of mozzarella containing only 10 percent fat by weight that has melting and textural properties similar to those of commercial full-fat mozzarella," says Edyth Malin, an ARS chemist at the Eastern Regional Research Center (ERRC) in Philadelphia, Pennsylvania.

"It's a significant accomplishment," Malin says, "considering that regular mozzarella contains about 22-24 percent fat, by weight, and part-skim typically has 17 percent."

The 10-percent-fat mozzarella is being evaluated by USDA's Food and Nutrition Service (FNS) for possible inclusion in the National School Lunch Program. Developed by the ERRC's Dairy Products Research Unit, the technology is helping solve a dilemma many parents and school cafeteria officials currently face: offering children dairy products rich in calcium and protein while reducing their dietary fat.

Schoolchildren now consume pizzas topped with cheese containing about 20 percent fat. As a result, more than 40 percent of the calories in a pizza serving are contributed by the fat, Malin says.

Dietary Guidelines for Americans that were developed jointly by USDA and the Department of Health and Human Services call for less than 30 percent of calories from fat per day. Cheese topping contributes most of the meal's fat when pizza is served in school lunches.

Americans consume about 100 acres of pizza each day. This translates to an average of 7.7 pounds of that delicious, stringy mozzarella cheese topping, per person, each year.

"New low-fat products like this are important as we work to provide children with appealing meals that comply with the dietary guidelines," says Ellen Haas, USDA's Assistant Secretary for Food and Consumer Services. "Common sense tells us that when the market learns that USDA wants to buy low-fat mozzarella, there will be plenty of low-fat mozzarella to buy."

Last May, ARS, FNS, and the School District of Philadelphia decided to let kids evaluate the new mozzarella. Five-inch pizzas topped with the ARS low-fat cheese were served to students at Shawmont Elementary and Jones Middle School.

"It was pretty good," says Nekesa Parks, a 14-year-old student at Jones. "It had a real cheesy texture."

Most students interviewed at Jones say that if given a choice of low-fat mozzarellas as toppings for pizzas in their school lunches, they would choose the mozzarella that best simulated the melting, texture, and flavor characteristics of full-fat mozzarella.

"I would take the one that's better...the one that's good for you," says 8th-grader James O'Neil.

Jose Morales, a 5th-grader, pretty much summed up his response by pulling the cheese from the crust and devouring it in one gulp. "The cheese is real good," he says.

"At Jones, most of the students finished the pizzas, which is an indication that they find the cheese acceptable," says ARS chemist Michael Tunick. "The responses were similar from children at Shawmont, including one youngster who refused to go out for recess until she finished her pizza."

How Do They Do It?

Tunick says the ARS mozzarella is produced using normal cheesemaking procedures, equipment, and cooking time. However, the researchers reduced cooking temperatures from 110°F to 95°-99°F.

Lower cooking temperatures are important for the survival of starter-culture bacteria, as well as of enzymes that are both found naturally in milk and added during cheese production. These enzymes are critical to breaking apart milk proteins into smaller units called peptides—a process known as proteolysis.

Cheese is made up mostly of protein chains that are tightly coiled up. It would be inedible if it weren't softened by enzyme action and the presence of moisture.

With the new cheese, "Lower cooking temperatures and the resulting higher moisture content increase the survival of enzymes such as rennet, the one that is added to milk to clot the proteins into a curd," Malin says. "Consequently, a larger number of enzymes are available to go to work breaking down the milk proteins into smaller peptides.

"The increased proteolysis of milk proteins makes a softer cheese with texture and melting characteristics of regular mozzarella."

According to Tunick, the scientists found that refrigerating the low-fat mozzarella right after cheesemaking, at 40°F for up to 6 weeks, enhances meltability. "That's because the breakdown of milk proteins by enzymes and starter culture bacteria continues during storage.

"This development is good news for both health-conscious consumers and the pizza industry," Tunick says. "Most of the 1.8 billion pounds of mozzarella consumed annually in the United States enters the market at the wholesale level for use by food processors and restaurants in the manufacture of pizza."

Malin uses molecular modeling to study the textural characteristics of the low-fat mozzarella. Three-dimensional views of molecules allow ERRC scientists to simulate the proteolytic process. This lets them see how the peptides improve texture and meltability by breaking up the dense protein body of the cheese.

A patent application has been filed on modifications to the technology developed by Malin and Tunick and ERRC co-inventors Virginia H. Holsinger, and Philip W. Smith.

The patented technology is available for license by industry, says Stephen Feairheller, a coordinator with ARS' Office of Technology Transfer.—By **Bruce Kinzel**, ARS

SCOTT BAUER

Chemist Edyth Malin uses molecular modeling to predict the structure of casein peptides formed as cheese ripens. (K5559-6)

Edyth L. Malin, Michael H. Tunick, Virginia H. Holsinger, and Philip W. Smith are in the USDA-ARS Dairy Products Research Unit, Eastern Regional Research Center, 600 E. Mermaid Lane, Philadelphia, PA 19118; phone (215) 233-6444, fax (215) 233-6795.

Stephen Feairheller is with ARS Office of Technology Transfer, Philadelphia Office; phone (215) 233-6610, fax (215) 233-6777. ◆

ONWARD VERNONIA!

JACK DYKINGA

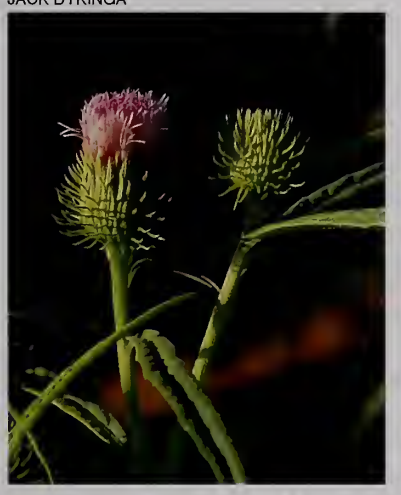
Vernonia seeds. (K5569-1)

Thanks to advances in plant breeding, vernonia is closer to becoming a viable new crop for U.S. farmers, providing them additional income and consumers new and improved paints, varnishes, and plastics.

Agricultural Research Service scientists in the U.S. Water Conservation Laboratory in Phoenix, Arizona, have succeeded in breeding strains of *Vernonia galamensis,* native to equatorial Africa, that will grow in this country.

"Normally, our growing season is too short and plants fail to flower and produce seed before frost. The new plants now flower during the summer's long days," says plant geneticist Anson E. Thompson, who recently retired from ARS.

JACK DYKINGA



Vernonia flowers. (K5568-1)

One wild strain known as petitiana was collected from Ethiopia by ARS botanist Robert E. Perdue, Jr. Less delicate than other strains, it provided the Phoenix scientists key genetic material for new lines that readily thrive in diverse U.S. climates.

This past winter, 34 lines with the most promise were grown and harvested by ARS cooperators at Mayaguez, Puerto Rico. Seed was shared with scientists in Georgia, Iowa, Idaho, Louisiana, Missouri, New Mexico, Oklahoma, Oregon, Texas, and Virginia. They hope to select lines best adapted to their unique climates and soils.

Studies last year indicated that seed oil content ranged from a high of 41.8 percent in Virginia to a low of 36.5 percent in Iowa. Seed weight ranged from 2.75 grams per 1,000 seeds in Oregon to 2.1 in Texas.

"This suggests that some areas may be more favorable than others for producing vernonia. It's too early to predict where vernonia will do best, but it looks like highly productive plants can be bred for our temperate zone," says David A. Dierig, an ARS plant geneticist at Phoenix.

One potential new use for vernonia oil might be as a drying agent in reformulated oil-based or alkyd-resin paints. Some 325 million gallons of these paints are manufactured annually in the United States, and the drying agents currently used are major air pollutants. One study shows that, in the Los Angeles area alone, as much as 22 tons per day of volatile organic compounds are released into the air from paints and varnishes. Use of vernonia oil in paint would require that some 365,000 acres be grown annually.

Other uses for vernonia oil could be in the manufacture of new types of plastics called interpenetrating polymer networks—tough, rubbery plastics. The oil can also form clear, tough yet flexible baked coatings on metal.

But the plant still needs seeds that hold tight as they near maturity so they can be machine-harvested.

Currently, maturing seeds resemble those of the dandelion and are easily blown away by wind—a valuable trait in the wild, but not for commercial production. It might be possible to work around this botanical feature by selecting and breeding plants for improved seed retention, spraying plants with a drying agent before harvest, or cutting immature plants and allowing them to dry in swaths until seeds are dry.

"We are confident we can solve the seed retention problem," says Dierig. "However, we will need more information on the plant's water and fertilizer needs—how much and when to apply. Also, weeds that pose no threat to currently cultivated crops might overwhelm vernonia."

Partial funding for this research is provided by the U.S. Department of Defense and USDA's Cooperative State Research Service.

Private industry is showing keen interest in vernonia, too; one commercial company is growing 500 acres so it can obtain enough oil for testing and product development.—By **Dennis Senft,** ARS.

David A. Dierig is at the USDA-ARS U.S. Water Conservation Laboratory, 4331 E. Broadway Rd., Phoenix, AZ 85040; phone (602) 379-4356, fax (602) 379-4355. ◆

In a test plot near Phoenix, Arizona, geneticist David Dierig measures the growth of vernonia. (K5567-1)

JACK DYKINGA

Technology Tattles on Mastitis

Cells taken from the lining of dairy cow mammary glands are shedding new light on how milk is produced and how bacteria infect the cells and ultimately cause mastitis.

"Mastitis is a bacterial infection of the mammary glands of dairy cattle," says physiologist Albert J. Guidry, who is with the ARS Milk Secretion and Mastitis Laboratory in Beltsville, Maryland.

Mastitis costs U.S. farmers over $2 billion annually for treatment and lost milk production.

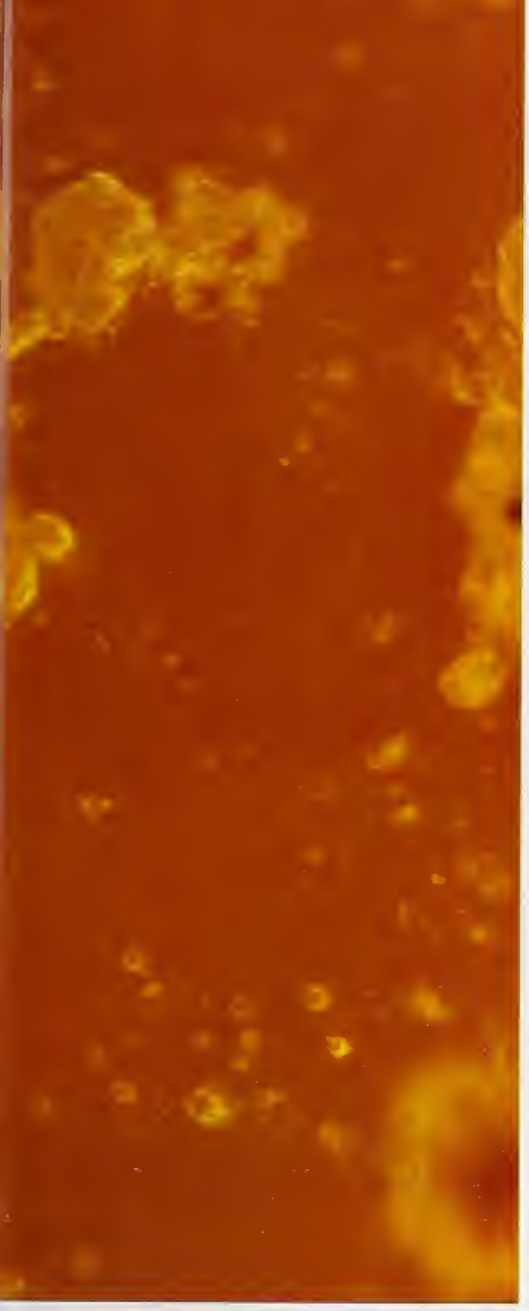
Preliminary studies have shown that cultures of mammary cells grown in single cell layers, or monolayers, can be used to show the effect of bacterial toxins on mammary cells. These toxins are substances manufactured by bacteria that can injure or kill healthy cells.

Scientists now have a method to compare and measure how bacterial toxins affect mammary cells.

They grow monolayers of cells in 96-well culture plates treated with a compound that makes healthy cells fluoresce. Fluorescence decreases when the cells are exposed to membrane-damaging bacterial toxin. The scientists then use a fluorometer to measure the decrease, for comparison with the fluorescence of monolayers receiving no toxin.

The next step is to run similar tests using live, toxin-producing bacteria and compare the results," Guidry says. "Electron micrograph studies of the infected cells should reveal how the bacteria infect the cells and could lead to methods to control them.

"Previously, we could only speculate on the events taking place inside the infected mammary gland.



Large photo shows bovine mammary secretory cells (magnified 75 times) forming lobelike structures connected by drainage ducts. (94-95)
EDUARDO CIFRIAN

Inset: Physiologist Albert Guidry retrieves mammary secretory cells that have been frozen in liquid nitrogen at minus 145°C for more than a year. Cryogenic storage allows researchers to conduct multiple experiments on cells of the same cow over extended periods of time. (K5570-1)
KEITH WELLER

If mammary cells are maintained for 10 to 12 days on certain types of culture media, small ducts or tubules grow and secrete protein as they would in a live animal.

It was a 'black box' that only grudgingly yielded its secrets," Guidry says.

"We wanted a system in which we could introduce infectious bacteria and directly observe cell and bacterial interaction. So now we have the inside layer of mammary secretory cells growing on a flat surface that we can observe under the microscope and measure various cell functions."

The scientists obtain the mammary epithelial cells at slaughter by enzyme digestion. They grow the cell suspension in a culture medium and freeze it for later use.

"Experimenting with these cells will reduce the number of live animals required for laboratory tests," says veterinarian Eduardo Cifrian, who is on leave from the National Institute for Research in Agriculture of Spain.

"Our tests have shown that these are normal mammary secretory/excretory cells. They produce the milk proteins alpha and beta casein, alpha-lactalbumin, and lactoferrin. The cells also produce cytokeratin, which is unique to epithelial cells," Cifrian says.

This cell culture technique will enable scientists to determine how mammary cells produce milk. Studies are also under way to determine how growth hormone affects mammary cells.

Other scientists at Beltsville are exploring the possibility of using the cultures to test genetically engineered gene constructs before introducing them into embryos.

Recent studies using pigs and sheep have shown that it is possible to insert into farm animals genes that cause them to produce lifesaving biologicals—such as blood clotting factors for hemophiliacs—in their milk.

"Testing genetically engineered constructs in cultured cells derived from mammary glands would save both animals and time," says ARS geneticist Robert J. Wall.

An unusual feature of these cultured cells is the formation of mini-mammary glands. If the cells are maintained in culture for 10 to 12 days on certain types of culture media, small ducts or tubules grow and secrete protein as they would in the live animal.

Growing milk in culture bottles is not on the horizon. However, "understanding how the milk-producing cells respond to various nutrients and hormones and to bacterial infection may guide us to more efficient milk production and a practical, environmentally sound means to prevent mastitis," says Guidry.—By **Vince Mazzola,** formerly with ARS.

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REGIS LEFEBURE

Cleaner Chicken Ahead

To determine levels of chlorine dioxide and its byproducts, chemist Lee Tsai prepares a water sample for analysis in a high-performance liquid chromatograph. (K5575-2)

As one of the final steps in preparing ready-to-cook chicken and turkey, raw carcasses—already defeathered and eviscerated—are submerged in icy water. The bath chills the birds to 40°F or lower, preserving freshness and lengthening shelf life.

The bird's own high body temperature and the hot water used in defeathering mean that carcasses entering this bath are always warm. Immersion takes about an hour, according to food safety researcher Lee S. Tsai of the ARS Western Regional Research Center in Albany, California.

Thousands of poultry carcasses share these communal tubs. To prevent microorganisms carried by some chickens from contaminating the water and infecting other birds in the bath, many processors use chlorine to sanitize the water. "The bath," Tsai says, "is a critical point in the plant's control of cross-contamination by these microorganisms."

Now, in a 1-year-study, Tsai and colleagues in the Food Safety and Health Research Unit at Albany have taken a new look at a chemical—chlorine dioxide—that could be used to disinfect chiller water. The scientists say chlorine dioxide offers several advantages over chlorine, the most widely used sanitizer in poultry production.

In their study, the scientists confirmed chlorine dioxide's effectiveness in killing bacteria. That includes such pathogens as *Salmonella, Listeria, Escherichia coli, Campylobacter,* and *Entobacteriaceae.*

The researchers also showed that chlorine dioxide won't form mutagens when used in practical amounts to sanitize the chiller water. Mutagens are compounds that can cause cells to change or mutate, sometimes with harmful results.

Bacterial and mutagenicity screens were part of a series of laboratory

assays to scrutinize the chemical's safety and effectiveness. In all, the ARS study is likely the first to provide a thorough look at what happens to chlorine dioxide once it's added to chiller water.

"Chlorine dioxide is more expensive than chlorine, but you can use less of it and get just as good bactericidal results," says Tsai.

Chlorine is an element—that is, a substance that can't be broken into a simpler substance. Chlorine dioxide is a compound made by mixing another chemical, chlorite, with chlorine gas.

Tsai worked with ARS colleagues Fe Molyneux, Virginia Randall (now retired), John Schade, Kenneth Stevens, and Robert Wilson, who analyzed chiller water samples from a California poultry processing plant.

Chlorine dioxide, according to Tsai, was about five times more powerful as a bactericide than chlorine. Adding 20 to 30 parts per million of chlorine dioxide to chiller water in the laboratory test reduced bacterial counts from initial levels of 12,000 to 14,000 colony-forming units per milliliter to less than 10 cfu/ml, in only 3 to 5 minutes. (One part per million is the same as 1 ounce in 7,800 gallons. A milliliter is about one-thirtieth of an ounce.)

It took 100 to 150 ppm of chlorine, or up to five times as much chemical, to get the same level of disinfection, Tsai notes. Processing plants that add chlorine to chiller water typically use about 20 to 50 ppm.

With a standard test for screening mutagens, the scientists demonstrated that chlorine will form mutagens in chiller water, while chlorine dioxide will not—when both are tested at comparable levels of potency.

Furthermore, chiller water can accumulate bits of chicken fat and proteins that leach out of the carcasses. Chlorine oxidizes these compounds to form contaminants such as carbonyl compounds. "Carbonyls," says Tsai, "are commonly linked to off-flavor in meats."

An assay for measuring oxidation—the thiobarbituric acid test—uses malonaldehyde, a key carbonyl, as an indicator. Adding chlorine dioxide to chiller water does not significantly increase this carbonyl, Tsai reports.

The scientists say chlorine dioxide offers several advantages over chlorine, the most widely used sanitizer in poultry production.

Chlorine dioxide will, however, form chlorite—a chemical that's regulated in drinking water. When tested in the lab at 20 ppm, for example, about half of the chlorine dioxide in chiller water became chlorite, the scientists found. In the processing plant, the amount may be less. In any case, says Tsai, chlorite levels would need to be taken into account when determining safe quantities of chlorine dioxide to use in chiller water.

The idea of adding chlorine dioxide to poultry chiller water isn't new. The compound was used in the 1970's as an alternative to chlorine. Then, a change in federal policy meant poultry processors could no longer use the chemical for disinfecting chiller water.

Today, processors of fruits and vegetables rely on chlorine dioxide to disinfect water used to wash, move, and cool produce. And more than 500 municipalities around the country have chosen it to sanitize drinking water.

A collaborator in the Albany experiment, Rio Linda Chemical Company of Sacramento, California, has petitioned the federal government for approval of chlorine dioxide for sanitizing chiller water. The company, a major manufacturer and distributor of equipment and chemicals for producing chlorine dioxide, anticipates a response this year.

Because chlorine dioxide is hazardous to transport, poultry processors would have to make their own supply of the gas on site. The gas would be dissolved in water that's then pumped to the chiller tanks.

Rio Linda Chemical Company included the Albany study in its petition, along with an earlier report by Huda S. Lillard of the ARS Microbiological Safety Research Unit in Athens, Georgia. Lillard's experiment, conducted in the late 1970's, also indicated that chlorine dioxide was more effective as a bactericide than chlorine.

Chiller baths cool about 7 billion chickens and 267 million turkeys every year. The average American eats about 86 pounds of poultry a year. Broilers return about $10 billion to growers; turkeys about $2.5 billion.—By **Marcia Wood,** ARS.

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Huda S. Lillard is in the USDA-ARS Microbiological Safety Research Unit, Richard B. Russell Agricultural Research Center, P.O. Box 5677, Athens, GA 30613; phone (706) 546-3567, fax (706) 546-3771. ◆

Monitoring Water Gain During Pregnancy

Tomorrow's obstetricians may rely on a technique called bioimpedance spectroscopy—or BIS—to monitor water gain in their pregnant patients.

"Mothers-to-be should gain 25 to 35 pounds during their pregnancy for a healthy baby, according to the newest recommendation from the federal government," says ARS researcher Marta D. Van Loan.

"Some of that weight gain will be fat. But the single biggest component will be water. BIS is a fast, simple way to monitor the water gain. And it's painless, safe, and convenient."

BIS estimates the total amount of water that's in the body and indicates how much is inside or outside of cells. All healthy cells have water both inside and out, explains Van Loan, a research physiologist. But buildup of water outside the cells is of special concern during pregnancy because it can lead to edema, a sometimes painful condition that's common in expectant mothers.

Van Loan studied the BIS technique with 10 pregnant volunteers, aged 20 to 37. Though BIS isn't new, Van Loan is likely the first to explore its use in monitoring the health of pregnant women. She did the work at the ARS Western Human Nutrition Research Center in San Francisco.

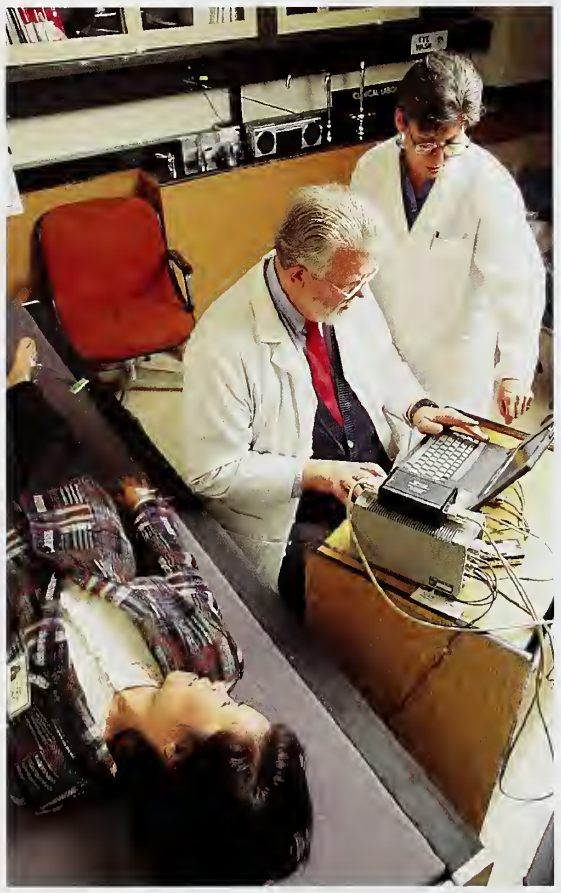
Measurements take about 2 minutes, according to Van Loan. Her preliminary results indicate that BIS is just as accurate as the sodium bromide dilution method, an established technique.

The dilution method, however, is less convenient.

It requires taking a blood sample, having the patient drink a glass of water containing sodium bromide ("tastes like seawater," says Van Loan), then taking another blood sample about 5 hours later.

To make a bioimpedance measurement, the physician simply places electrodes on the patient's hand and foot, then switches on the bioimpedance device, or spectrometer. The instrument conducts a current—a harmless range of consecutive frequencies—to the electrodes and through the body. Impedance, or resistance to this sweep of electrical charges, is measured.

REGIS LEFEBURE



Physiologist Marta Van Loan (standing) and technician Patrick Mayclin check water weight gain measurements in volunteer Thuan Dao. A math teacher at Pinole (California) Valley High School, Dao is participating in the ARS Summer Teacher Fellowship Program. (K5573-1)

"Extracellular water—the water that's outside of cells—will offer little or no resistance to any current," Van Loan says. "That's because water is a good conductor of electricity. But the membranes that enclose cells will impede movement of a low-frequency current through those cells. BIS distinguishes water that's outside or inside of cells by detecting differences in resistance as the current travels easily through water or is impeded by cell membranes."

A personal computer linked to the spectrometer logs the measurements, processes them through mathematical equations contained in the software, and prints out an estimate of the patient's extra- and intracellular water load.

Van Loan took volunteers' BIS measurements before conception, to establish a baseline. She remeasured them at three intervals during the pregnancies and at about 4 weeks after childbirth.

She worked with Patrick L. Mayclin, also of the ARS laboratory in San Francisco; William W. Wong of the ARS Children's Nutrition Research Center in Houston, Texas; James Matthie at Xitron Technologies, San Diego, California, and Lori E. Kopp and Janet C. King of the University of California at Berkeley's Department of Nutritional Sciences. The San Francisco study was part of a larger experiment directed by King.

Scientists at other research centers throughout the country are investigating additional new applications of bioimpedance spectroscopy, including monitoring of kidney dialysis and critical care patients.—By **Marcia Wood,** ARS.

Marta D. Van Loan and Patrick L. Mayclin are at the USDA-ARS Western Human Nutrition Research Center, P.O. Box 29997, Presidio of San Francisco, CA 94129; phone (415) 556-5729, fax (415) 556-1432.

William W. Wong is with the USDA-ARS Children's Nutrition Research Center, 1100 Bates St., Houston, TX 77030; phone (713) 798-7168; fax (713) 798-7119. ◆

Science Update

Beneficial Bacteria Crowd Out the Bad Guys in Poultry

Helpful bacteria could be a natural tool for keeping poultry free of harmful campylobacter and salmonella bacteria that cause food poisoning. The helpful bacteria already occur in adult chicken intestines. Now, ARS is patenting their use to colonize a chick's intestines—to crowd out, or outcompete, these two organisms that cause human disease. In studies, the approach has reduced—by 99 percent or more—the number of disease organisms in chick intestines. Newly hatched chicks are aerosol-sprayed with the beneficial bacteria and get a second dose in their first drinking water. One key, say the scientists, is to culture the beneficial bacteria in the absence of oxygen. That approach most closely mirrors conditions in the chick's intestines. *Norman J. Stern, USDA-ARS Richard B. Russell Agricultural Research Center, Athens, Georgia; phone (706) 546-3516.*

Cholesterol Cousin Could Be New Piece of Heart Disease Puzzle

In people with high cholesterol, a little-known blood lipid may further increase the risk of heart disease. This suggestion emerges from an ARS study of Lp(a), a cousin to that well known artery-clogger, LDL cholesterol. In the new study, scientists measured Lp(a) in 623 men who had taken part in a 10-year coronary prevention trial funded by the National Heart, Lung, and Blood Institute. All began that 10-year trial with higher than recommended levels of total and LDL cholesterol. But the ARS study found that Lp(a) was 21 percent higher in those who had a heart attack 7 to 10 years later, compared to those who stayed healthy. This ran counter to earlier studies, which were about half as long—perhaps not long enough for slowly progressive heart disease to be evident. Scientists speculate that apolipoprotein(a), a protein found in Lp(a), but not in LDL, may interfere with the body's efforts to remove clots from arteries. *Ernst J. Schaefer, M.D., USDA-ARS Human Nutrition Research Center on Aging, Boston, Massachusetts; phone (617) 556-3100.*

Will Leafminer Pest Cave In to Biocontrols?

Sprays of fungi, bacteria, viruses, and nematodes are being tested as natural controls for citrus leafminers, new pests of Florida citrus. First appearing last year, the fast-spreading insect now looms as a threat to Florida citrus groves and nurseries. Chemical sprays often miss the leafminer, which hides in tunnels it fashions inside leaves. This past summer, scientists evaluated sprays of natural pathogens mixed with a surfactant compound to enhance their activity. The pathogens include *Paecilomyces* and *Metarhizium* fungi, *Bacillus thuringiensis* bacteria, nuclearpolyhedrosis virus, and *Steinernema carpocapsae* and *S. riobravis* nematodes. None of the biocontrols is harmful to beneficial insects, and all except the fungi are commercially available. *Jeffrey P. Shapiro and William J. Schroeder, USDA-ARS U.S. Horticultural Research Laboratory, Orlando, Florida; phone (407) 897-7300.*

Gene Found To Control Tomato Sugar

Tomorrow's tomatoes could be tastier and sweeten production for processors, because an ARS scientist has found a tomato gene that regulates the type of sugar the fruit accumulates. The scientist hopes the gene, which he calls *sucr,* can be used for genetically altering the types and relative amounts of tomato sugars. That could boost flavor, which is affected by variations in sugar as well as acid content. Plus, more tomato sugars would mean more processed product, because sugars currently make up about half of the tomato solids vital to processors. *John R. Stommel, USDA-ARS Vegetable Laboratory, Beltsville, Maryland; phone (301) 504-5583.*

Hairy Vetch Mulch Covers the Tomato Patch

Under a cooperative R&D agreement with ARS, Starkey Farms of Galena, Maryland, grew fresh-market tomatoes this summer using hairy vetch plants as mulch—instead of the usual nonbiodegradable plastic variety. ARS scientists developed and tested this system for using the vetch, a legume, as the linchpin for a low-input, no tillage, sustainable agricultural system. It prevents erosion, makes soil more fertile, improves tomato quality, and raises yields up to 40 percent. Previous ARS studies showed that it lowered production costs an estimated $800 per acre by eliminating plastic mulch and reducing tillage, fertilizer, and herbicides. Two other vegetable growers are trying the system—Bramhall Family Farm in Lothian, Maryland, and Butterfly Hill Farm in Lovettsville, Virginia. *Aref Abdul-Baki, USDA-ARS Vegetable Laboratory, Beltsville, Maryland; phone (301) 504-5057.*

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Upcoming in the OCTOBER Issue

☛ A special look at how ARS research has shaped the American dinner table. From the renowned Charleston Gray watermelon to the stiff-strawed wheat that helped spark the Green Revolution, ARS scientists have contributed to the productivity, flavor, and nutritional value of many crops.